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# Deepening Implementation of "Shiptime Sharing Project", Promote Original Innovation of Marine Science and Technology

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# Deepening Implementation of "Shiptime Sharing Project", Promote Original Innovation of Marine Science and Technology


## Abstract

The "Shiptime Sharing Project" is a new exploration of the funding model of the National Natural Science Foundation of China (NSFC). After ten years of implementation, it has achieved significant effect which guaranteed the needs of marine surveys for NSFC funded projects. It has established a marine field observation platform for both interdisciplinary research and the training of young research scientists. It has promoted the accumulation and sharing of marine survey data as well as the overall development of marine science. Facing the new trend of global technology and economic development, the national strategic demand puts forward higher requirements for the "Shiptime Sharing Project". It is urgent to further enhance the strategic positioning of the plan, optimize and innovate the management mechanism, and increase the scale of funding.



## Keywords

marine scientific survey; research vessel; Shiptime Sharing Project; marine science and technology; innovation; National Natural Science Foundation of China (NSFC)



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# Deepening the Implementation of "Shiptime Sharing Project" to Promote Original Innovation of Marine Science and Technology

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**Abstract:** The "Shiptime Sharing Project" is a new exploration of the funding model of the National Natural Science Foundation of China (NSFC). After eleven years of implementation, it has achieved significant effect which guaranteed the needs of marine surveys for NSFC-funded projects. It has established a marine field observation platform for both interdisciplinary research and the training of young research scientists. It has promoted the accumulation and sharing of marine survey data as well as the overall development of marine science. Facing the new trend of global technology and economic development, the national strategic demand puts forward higher requirements for the "Shiptime Sharing Project." It is urgent to further enhance the strategic positioning of the plan, optimize and innovate the management mechanism, and increase the scale of funding.
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**Keywords:** marine survey; research vessel; Shiptime Sharing Project; marine science and technology; innovation; National Natural Science Foundation of China (NSFC)

Marine science needs data support from field observations. It is the original power and prerequisite for the progress of marine science to obtain first-hand data and samples through field observation via marine research vessel. In 2009, the National Natural Science Foundation of China (NSFC) launched the "Marine Research Shiptime Project," namely, the "NSFC Shiptime Sharing Project" (hereinafter referred to as "Shiptime Sharing Project"). This project aims to coordinate the needs of marine survey of NSFC-funded projects with the efficient use of marine research vessels through reasonable and effective deployment of the marine research vessels, which is a new method for the "Opening and Sharing of Marine Research Ships in China." The past 11 years witnesses the stable implementation of the "Shiptime Sharing Project," which is a new funding mode. Via this project, a marine field observation platform for both interdisciplinary research and the training of young research scientists has been established. It has promoted the accumulation and sharing of marine survey data as well as the overall development of marine science.

At present, marine research vessels, as the key and basic support for exploring the sea, are important for marine technological innovation. As compared the international large-scale marine survey plan and international management mode of marine research vessels, China's "Shiptime Sharing Project" needs to further optimize the strategic positioning and management, so that the funding scale can meet the national strategic needs. In this paper, we summarized the achievements of "Shiptime Sharing Project" and described the development trend of international marine survey. On this basis, we analyzed the challenges of the "Shiptime Sharing Project" and put forward the ideas and suggestions for its future development.

## 1 Remarkable achievements of "Shiptime Sharing Project" in 11 years

Since the "Shiptime Sharing Project" was launched in 2009, NSFC has earmarked 430 million CNY for long-term, continuous, comprehensive observation of China's offshores, western Pacific, and eastern Indian Ocean by 101 voyages. Via the 19 marine research vessels provided by 10 research institutions of Chinese Academy of Sciences, Ministry of Education, Ministry of Natural Resources, and Ministry of Agriculture and Rural Affairs of the People's Republic of China, the "Shiptime Sharing Project" has helped 6 000 researchers from 115 research institutes and universities with field survey of the marine, and 1 471 NSFC-funded projects to obtain the first-hand observation data, supporting over 3 000 papers. With the help of "Shiptime Sharing Project," a large number of fund projects manage to overcome the difficulties brought by the lack of observation platform, greatly enhancing the sharing of oceanic observation data, interdisciplinary

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research, and innovative research. A total of 49 scientists have served as chief scientists of the 101 voyages (64.4% younger than 45, with the minimum age of 30 and average age of 43.7). A total of 481 youth fund projects (32.6% of all the approved projects) have completed the marine surveys via the shared voyages, which promotes the development of interdisciplinary talents in marine research.

The "Shiptime Sharing Project" has been widely recognized by researchers in marine field and highly regarded by evaluation experts. In summary, the achievements of the "Shiptime Sharing Project" are as follows [1,2]: (1) serving as a new mode of science funding in line with international standards, (2) providing a platform for marine survey and interdisciplinary cooperation, (3) training young talents, and (4) promoting the accumulation and sharing of data about marine survey.

"Shiptime Sharing Project" promotes the overall development of marine science. "Shiptime Sharing Project" was launched at the rapid development stage of science foundtion-funded projects. Facing the rapid growth of appropriations and funded scale, "Shiptime Sharing Project" provides a platform for marine survey of funded projects and their co-operators and breaks the bottleneck of marine research. Statistics show that the applications of NSFC projects in marine science (D06) increase significantly since the implementation of the "Shiptime Sharing Project" and that the increase rate rises greatly as compared with that in 2006–2008 (Figure 1). Thus, the institutions with no marine research vessels have significantly more opportunities to apply for the projects in marine science (Figure 2) and more institutions would like to join the basic research of marine science. The supported organizations increase from 151 in 2009 to 295 in 2019. The 11 years see totally 378 new applicants and 321 new cooperating organizations, with the average annual new applicants of 34 and new cooperating organizations of 30. Among them, approximately 11 cooperating organizations independently apply for D06 projects as supported organizations after participating in the "Shiptime Sharing Project."

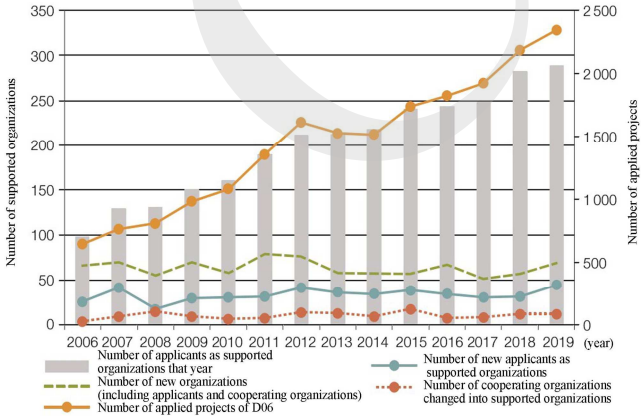


**Figure 1** Number of applied projects of National Natural Science Foundation of China in marine science (D06) and number of supported organizations from 2006 to 2019

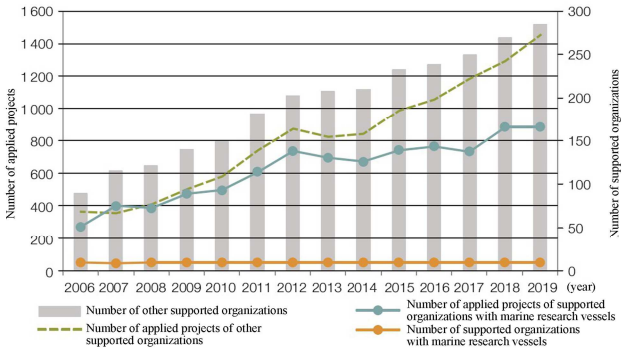


**Figure 2** Number of applied projects of supported organizations with marine research vessels and other supported organizations

The supported organizations with marine research vessels include the First Institute of Oceanography, Second Institute of Oceanography, Third Institute of Oceanography, Ministry of Natural Resources of the People's Republic of China, Qingdao Institute of Marine Geology, China Geological Survey, Polar Research Institute of China, Institute of Oceanology, Chinese Academy of Sciences, South China Sea Institute of Oceanology, Chinese Academy of Sciences, Ocean University of China, Yellow Sea Fisheries Research Institute, Chinese Academy of Fishery Sciences, and East China Sea Fisheries Research Institute, Chinese Academy of Fishery Sciences. Other supported organizations include all the supported organizations applied for D06 projects except for the supported organizations with marine research vessels.

## 2 Development trend of international marine survey

In the past, we mainly relied on marine research vessels to explore the sea. With the rapid development of various oceanographic instruments and technologies such as satellite, aviation remote sensing, buoy, and submersible, marine research has gradually expanded from aerospace, ocean surface, ocean profile, ocean bottom, and offshore drilling to the networking real-time continuous observation with serialized three-dimensional techniques [3]. At present, more than 10 international marine observation/exploration systems with the coverage from regional scale to the global scale have been established [4], which have provided tremendous observation and exploration data for global climate prediction, marine activity forecasting, and protection of marine ecological environment, and research on major marine scientific and technological problems, thus significantly improving the ability of humans in recognizing, using, and protecting the ocean. In the modern marine observation system, with multiple functions such as observation, sampling, and new technology testing, marine research vessels play a core, basic, and irreplaceable role and are a direct tool and comprehensive platform for obtaining marine information [5].

### 2.1 Marine research vessels-based international surveys

The research vessels/drilling vessels-based marine surveys mainly include Global Ocean Ship-Based Hydrographic Investigations Program (GO-SHIP) and International Ocean Discovery Program (IODP) (2013–2023).

(1) GO-SHIP: Its mission is to organize the global hydrological investigation once every 10 years for the purpose of obtaining valuable repeated observation data [6]. GO-SHIP mainly involves multidisciplinary comprehensive observation of the whole ocean basin and water depth (from the sea surface to the bottom) based on marine research vessels, with the highest measurement accuracy among all hydrological survey methods.

(2) IODP: From the Deep Sea Drilling Program (DSDP) (1968–1983), it is the longest international science project in the field of earth sciences. The achievements of IODP have verified the theory of plate tectonics, revealed the rules of climatic revolution, discovering the subsurface biosphere and combustible ice, and promoting the major breakthroughs of earth sciences. China joined the Ocean Drilling Program (ODP, 1985–2003), the predecessor of IODP, in 1998. Later, on the basis of the Complementary Project Proposal (CPP), China completed three drillings in the South China Sea, which is a new research perspective for exploring the evolutionary mechanism of marginal seas [7].

The progress of the marine research vessels-based surveys shows that the major original achievements in marine science is highly dependent on the planned and organized marine field observations, and survey data accumulation, and discovery of new evidences. Marine research vessels have become an indispensable part of scientific and technological innovation.

## 2.2 Management model of international marine research vessels

In this part, we describe three major management modes of marine research vessels: University–National Oceanographic Laboratory System (UNOLS), GO-SHIP, and IODP.

(1) UNOLS: Through unified management and coordination, it realizes the reasonable arrangement of vessels and instruments, thus reducing the crossover and overlap of marine surveys [8]. Specifically, the voyage arrangements are flexible: (1) arranging one voyage for one scientific issue based on the vessels and equipment applied, (2) providing various types of training voyages, and (3) performing special voyage surveys on major scientific issues of international concern. Since the vessels and the corresponding instruments and equipment are purchased by the National Science Foundation (NSF) and other government agencies of the United States [9], guaranteeing the marine surveys of various fund projects and reflecting the inclusive characteristic.

(2) GO-SHIP: Unlike UNOLS, GO-SHIP, as an international organization, mainly advocates and organizes marine research vessels from various countries to participate in the global program through international agreements. Therefore, the scientific and thorough management mechanism is the key to its successful operation, including the scientific steering committee and an executive group, access policies for marine research vessels of various countries, GO-*SHIP Repeat Hydrography Manual*, and data sharing policies.

(3) IODP: Compared with the "inclusive" voyages of UNOLS, the voyages of IODP mainly focus on a major scientific issue. IODP proposal, namely the "scientific issue," is the key factor driving IODP [10]. The Science Evaluation Panel of IODP reviews IODP proposals submitted by scientists from various countries and selects the optimal ones for implementation. In addition, IODP has also established a complete achievement management and sharing mechanism [11].

According to the management modes of marine research vessels, the "Shiptime Sharing Project" of NSFC mainly adopts the mode of "inclusive" voyages. Although its management mode is like the UNOLS, the marine research vessels and instruments do not belong to the NSFC; in addition, only the marine research vessels are shared and the instruments and equipment are not included. Attempts have been made to arrange "scientific issue-guided" voyages, but they have not been included into the regular budget and there is currently not a corresponding management mechanism, creating a great gap from the IODP scientific issue-driven management mode. The Scientific Steering Committee and Data Sharing Policy Formulation Mechanism of the "Shiptime Sharing Project" are similar to those of GO-SHIP with the top-level design intent, but it lacks IODP's important achievement evaluation mechanism and sample distribution and sharing mechanism. In conclusion, the "Shiptime Sharing Project" is striving to expand the "scientific issue-guided" voyages and strengthen their management mode while maintaining the inherent characteristics and steady development. It is exactly the direction driven by the original innovation of China's marine science in the future.

## 2.3 Development frontiers of marine survey

With the development of science and technology, the performance and shipborne instruments of new marine research vessels have been improved. In the new era, the coverage of marine survey gradually changes from regions to global deep seas and oceans and from single discipline to multiple disciplines, as manifested by the following four aspects.

(1) Application of new technologies: By virtue of new materials, new energy, new sensors, and data calculation and transmission technologies, various types of observation platforms (such as underwater glider) can be used for large-scale and long-term autonomous observation and some other observation platforms (such as manned submersibles) can be used for in-situ observation, detection and sampling on the seabed with the support of the marine research vessels. The new observation platforms expand the scope and time of marine observation and realize global observation [12]. The global ocean covers approximately 71% of the Earth's surface. Thus, we put forward the following suggestions for marine survey: strengthening the development of AI-based unmanned marine observation platforms to improve the independent observation in the extreme environments in different oceans and enhancing the research development and

application of multi-disciplinary parameters and high-resolution sensors, to improve the accurate reproduction ability of complex marine environment. For example, National Aeronautics and Space Administration (NASA) has proposed Geosynchronous Littoral Imaging and Monitoring Radiometer (GLIMR) for the development of new sensors, and also a global, full-depth and multi-disciplinary international Argo plan with Argo buoy array [13,14].

(2) Cooperation among different countries and observation programs: According to the organizational forms of major international marine observation/exploration programs, international cooperation has become one of the main modes of marine survey. Cooperating with coastal countries breaks the barriers of the continental shelf and exclusive economic zones, thus improving the overall understanding of ocean. The Global Ocean Observing System, initiated and implemented by Intergovernmental Oceanographic Commission (IOC), World Meteorological Organization (WMO), International Council of Scientific Unions (ICSU), and United Nations Environment Programme (UNEP), seeks to coordinate all-round international cooperation under a unified marine observation framework [15]. At present, 13 regional alliances of global marine observation systems have been established, which have adopted a variety of ways to enhance the cross-regional, group and technical collaboration in between [16]. Argo plan and GO-SHIP are important members of them.

(3) Sound management and sharing mechanism: A scientific and complete management mechanism is the key to the successful operation of large-scale international observation/exploration programs, which involves the observation standards and access systems, process management system, and the data management and sharing system. For the purpose of unified management, each observation plan has its own management organization or is dominated by the non-profit organizations such as national institutions or universities [4]. For example, the "Ocean Observatories Initiative" (OOI), supported and organized by NSF, aims to solve major scientific issues.

(4) Serving science and the society: The Ocean Obs'19 in Hawaii, the US, has one of the themes of "serving science and the society," aiming to (1) improve the marine observation system so that it can provide data for scientists and society to better understand the earth's environment, monitor the climate, and sustainably use the marine resources, and (2) provide professional training for young scientists. For example, GO-SHIP selects typical survey sections to train multidisciplinary observers in the fields of physics, chemistry, biology, and ecology. At the same time, in order to promote the international cooperation, it promises to provide more training opportunities for students from developing countries without marine research vessels, so as to achieve the sustainable development of marine observation [17].

## 3 Challenges of the "Shiptime Sharing Project"

Compared with the main international management modes of marine research vessels, the "Shiptime Sharing Project" is currently limited to "inclusive" voyages. In 2017, NSFC and the National Center for Science & Technology Evaluation entrusted a third party to evaluate the effect of the "Shiptime Sharing Project" in 2010–2016. The result showed that "Shiptime Sharing Project" had made remarkable achievements and that the funding mode and organization management, and data sharing should be further improved [2]. In the past two years, the Joint Planning Bureau of the Earth Science Division and Planning Bureau, NSFC, have been exploring the new management mode of the "Shiptime Sharing Project" so that it can continuously adapt to the management innovation of science fund and national strategic needs. With reference to the vigorous development of various marine observation programs, we believe that the "Shiptime Sharing Project" faces the following challenges.

### 3.1 Serving basic research in marine science

Specifically: (1) Almost all the 101 funded voyages, most were "inclusive" voyages and researchers collected data for their respective scientific issues on the same vessel. (2) Due to increasing needs of voyages and the funding gap of 30%–50%, the "inclusive" voyages had to constantly adjust routes and stations and reduce the time for each project and thus it is difficult to focus on major scientific issues. (3) The role of the chief scientist is unclear during the voyage (scientific survey project), and the scientific goal of a voyage is ignored. (4) The short execution cycle of the "Shiptime Sharing Project" would affect the design of the implementation plan for major scientific issues. Thus, the strategic positioning of the "Shiptime Sharing Project" should be improved. While completing the tasks of marine surveys for the funded projects, "Shiptime Sharing Project" should give priority to the basic research in marine science in China.

At present, the mission of NSFC is to deepen the reform and thus improving the innovation ability and reinforcing the innovation foundation are the primary task [18]. The strategic positioning of marine science innovation can only be improved and functional positioning of voyages guided by scientific issues can only be highlighted through deepening the basic supporting role of the "Shiptime Sharing Project."

### 3.2 Management mechanism

"Shiptime Sharing Project" has been classified into different projects for management. Due to the large number of sub-categories and annotation fields, the management method of the NSFC lacks pertinence for the "Shiptime Sharing Project." Therefore, in the future, the "Shiptime Sharing Project" should be further improved in the aspects of voyage type layout, training specification formulation and

training mechanism design, reasonable arrangement of project team, specifications for project responsibilities and rights, organization and coordination of voyages, data quality control and data management sharing, reward and punishment mechanism, project change procedures, and information management capability, thus forming a whole-chain management mechanism connecting all the processes.

### 3.3 Voyages in sensitive sea areas

As affected by changes in the world situation, it is common that the "Shiptime Sharing Project" cannot be implemented as scheduled or the routes cannot be designed according to the scientific objectives, which have affected the effectiveness of marine scientific activities. Due to the factors of topography, material input, and human activities, the hydrology, biochemistry, sediment, and other parameters of the continental shelf and sea areas around the island have changed drastically. They have always been key areas for marine surveys. Therefore, the prohibition of scientific research activities on the continental shelves and exclusive economic zones in the relevant countries or regions (including sensitive sea areas under the jurisdiction of China) would greatly affect frontier innovation research in marine science, and the fund management units and scientists should jointly propose the coping strategies.

### 3.4 Funds

The operation, maintenance, and upgrading of modern marine research vessels and survey equipment require a lot of funds. As for the current "Shiptime Sharing Project," the funds are limited to the operating expenses of marine research vessels, and the funding standard is lower than the actual expenses. Moreover, there is no extra fund for the testing and analysis of public samples, calibration of marine survey equipment, strategic research, data management, and sharing services. In addition, the "Shiptime Sharing Project" can not meet the needs of some projects, and the current voyages are limited to the coastal waters of China, the western Pacific, and the eastern Indian Ocean. It can not support the marine scientific research of the special projects of basic science of NSFC in polar regions, and there are no funds for surveys in ocean, deep sea, or abyss.

## 4 Suggestions on the development of the "Shiptime Sharing Project"

The development trend of international marine surveys shows that marine survey modernization is an important measure for accelerating the improvement of marine-related scientific research and original innovation in China. In the future, we should take advantages of NSFC, to enhance the basic supporting role of the "Shiptime Sharing Project," strengthen the top-level design, and improve the organization and management mode to make it more scientific, efficient, and shared, so that it can meet the needs of frontier innovation of marine science and marine power construction.

### 4.1 Increasing voyage types

The relatively simple organization mode of the "Shiptime Sharing Project" should be changed, and the targeted deployment should be adopted in combination with the development frontier of international marine survey while meeting needs of voyages.

(1) "Inclusive" voyage: In recent years, the number of marine-related universities and research institutes has been increasing, and the scientific research projects requiring marine surveys lack the opportunities for marine surveys. We should increase the "inclusive" voyages to meet the needs for the development of marine science. In addition, the "inclusive" voyages in the future should adopt more new technologies, new methods, and international standards for data collection, so as to achieve the long-term accumulation, synchronization, and comparability of the observational data. At the same time, we should fix the observation sections in typical sea areas, to enhance the advantages of China, improve the important scientific discovery capabilities, and expand the international influence.

(2) Major scientific survey voyages: Unlike the conventional "inclusive" voyages, the voyages for solving major scientific and technological issues rely on top-level design and strategic deployment, aiming to achieve major breakthroughs and original innovations. At the initial stage, such voyages can be preferentially provided for major projects funded by NSFC. In addition, the research direction with China's advantages can be formed based on prospective scientific and technological issues in the marine field recommended by experts or combined with the international observation plan to be determined and blank observation sea areas; then the voyages guided by major scientific and technological issues may be arranged to promote the intersection of cutting-edge disciplines and lead breakthroughs in original achievements.

(3) High-tech voyages: Deep-sea and abyss science is the frontier of earth system science and also the weakest and cutting-edge field in China's marine science. The key problem is the lack of the corresponding marine survey method. At present, China has successfully developed several types of sea seismographs, underwater gliders, and deep submergence vehicles, which, however, have not been widely used in scientific research. In the future, the "Shiptime Sharing Project" should design special voyages adopting the self-developed deep-sea and abyss detection equipment, so as to improve the comprehensive survey capacity of deep-sea and abyss. In addition, with reference to the UNOLS mode, we can construct the high-end equipment or special equipment library for the "Shiptime Sharing Project," and promote the upgrading of marine survey equipment and application of domestic high-end self-developed instruments through overall arrangements.

(4) Marine training voyages: International large-scale observation programs usually hold various professional trainings on marine research vessels for researchers going to sea [18], which has become an important measure for ensuring maritime surveys and cultivating innovative marine talents. Taking the composition of sea personnel of the "Shiptime Sharing Project" in 2016–2017 as an example, about 70% were master's candidates, whose capability of marine operations directly determined the safety quality of marine surveys. Therefore, the "Shiptime Sharing Project" should plan marine school (education) voyages, and explore to build a long-lasting platform for marine training integrating science and education basing on the "Shiptime Sharing Project," thus continuously improving the capacity and level of the corresponding marine personnel.

### 4.2 Optimizing management mechanism

The challenges to the management of the "Shiptime Sharing Project" can only be resolved through the optimization of the management mechanism. In February 2019, the Earth Science Division, NSFC issued the Implementation Plan of Shiptime Sharing Project of National Natural Science Foundation of China (Trial), which provided systematic solutions to the management problems in 10 years, which lays a policy basis for the application and acceptance, review and approval, as well as implementation and management, of the "Shiptime Sharing Project." According to the new reform requirements of the NSFC and the new development thinking of the "Shiptime Sharing Project," the management mechanism should be further optimized on this basis.

### 4.3 Expediting data sharing

In 2002, the Earth Science Division, NSFC entrusted and authorized the First Institute of Oceanography, Ministry of Natural Resources of the People's Republic of China to construct Ocean Data Center of NSFC (hereinafter referred to as the "Data Center"). Since the implementation of the "Shiptime Sharing Project" in 2009, the Data Center has played an important part in the implementation of voyage data collection and management. At the same time, the voyage project leader and chief scientist have conscientiously implemented the principle of "sharing on the same vessel," to make various observation materials and data preferentially shared at least between projects of the same voyage.

To expand the social and economic benefits of the funds earmarked by NSFC, the Earth Science Division, NSFC issued the Measures for the Management and Sharing of Survey Data of Shiptime Sharing Project of the National Natural Science Foundation of China (Trial) in August 2020, which will promote the classification and sharing of survey data and improve the level of open sharing, so as to meet the needs of scientific researchers for obtaining marine survey data.

### 4.4 Expanding international cooperation platform

The concept of "Maritime Community with a Shared Future" proposed by China and the "Decade of Ocean Science for Sustainable Development" (2021–2030) by the United Nations in 2021 will promote the development of marine science. At present, promoting global marine scientific research and global comprehensive marine observation has become a basic consensus of the international marine circle. The international scientific and technological cooperation platform will help to deepen scientific understanding of the global and regional ocean, thus providing a scientific basis for ocean management and sustainable development at global and regional levels.

In recent years, the Chinese Academy of Sciences and institutions of the Ministry of Natural Resources of the People's Republic of China have signed the joint research memorandum with the relevant national marine research institutions to promote the shared voyages. The shared voyages strengthen the marine science and technology exchanges with neighboring developing countries, expand the maritime survey area, and enhance international cooperation in marine scientific research.

In the future, the development of the "Shiptime Sharing Project" shall fully rely on the existing bilateral and multilateral cooperation mechanisms between the NSFC and other relevant national institutions, and the substantive maritime cooperation research with countries along the "Belt and Road" shall be actively planned, thereby strengthening and improving China's scientific research in the East China Sea, the South China Sea, the western Pacific and the eastern Indian Ocean and making effective efforts to establish a maritime community with a shared future and explore appropriate systems and mechanisms for maritime matters.


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